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Species Distribution of Mayfly (Ephemeroptera) Nymphs in Three Stream Systems in New Brunswick and Nova Scotia With Notes on Identification

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SPECIES DISTRIBUTIONS OF MAYFLY (EPHEMEROPTERA) NYMPHS IN THREE STREAM SYSTEMS IN NEW BRUNSWICK AND NOVA SCOTIA WITH NOTES ON IDENTIFICATION

by

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ABSTRACT

Peterson, R. H. 1989. Species distributions of mayfly (Ephemeroptera) nymphs in three stream systems in New Brunswick and Nova Scotia with notes on identification. Can. Tech. Rep. Fish. Aquat. Sci. 1685: iii + 14 p.

Fifty-eight sites on three Maritime stream systems (Saint Croix, Medway and Gold) were systematically sampled for invertebrates. Fifty-five mayfly (Ephemeroptera) taxa were identified, including at least six apparent extensions of known ranges (Ephemerella subvaria, Ephemerella aurivilli, Ephemerella tuberculata, Stenonema luteum, Stenonema mediopunctatum, Stenonema modestum). Four groups of mayflies were identified on the basis of apparent distributional patterns. The first group (at least 14 species) (Ephemerella subvaria, Ephemerella needhami, Ephemerella cornutella, Ephemerella deficiens, Ephemerella serratoides, Epeorus vitrea, Heptagenia hebe, Paraleptophlebia mollis, Tricorythodes sp., Baetis macdunnoughi, Baetis flavistriga, Baetis intercalaris, Baetis pluto and Baetis tricaudatus) were rarely collected from the acidic stream systems (Medway and Gold), but had limited distribution in at least one of them. For this group, distribution may be restricted by stream acidity. The second group consisted of seven species (Ephemerella dorothea, Ephemerella tuberculata, Ephemerella serrata, Stenonema mediopunctatum, Habrophlebiodes americana, Isonychia sp. 2, and Heterocleon curiosum) which were not present in either acidic system - either due to low pH or range limitation. A third group (at least five species: Ephemerella attenuata, Ephemerella funeralis, Stenonema modestum, Heptagenia sp., and Habrophlebia vibrans) were equally abundant in the acidic stream systems. A fourth group (two taxa) were more widely distributed in the acidic systems, hence are either adapted to low pH, or are tolerant and have benefited from the loss of competitive species.

An annotated list of the various species collected is provided, including identification aids and distributional information.

RÉSUMÉ

Peterson, R. H. 1989. Species distributions of mayfly (Ephemeroptera) nymphs in three stream systems in New Brunswick and Nova Scotia with notes on identification. Can. Tech. Rep. Fish. Aquat. Sci. 1685: iii + 14 p.

Cinquante-huit emplacements dans trois réseaux fluviaux des Maritimes (Sainte-Croix, Medway et Gold) ont été soumis à un échantillonnage systématique dans le but d'y recenser les invertébrés. Cinquante-cinq taxons d'éphémères (Ephemeroptera) ont été identifiés, y compris au moins six taxons qui semblaient déborder de leur aire géographique connue (Ephemerella subvaria, Ephemerella aurivilli, Ephemerella tuberculata, Stenonema luteum, Stenonema mediopunctatum, Stenonema modestum). Quatre groupes d'éphémères ont été identifiés d'après les modèles de distribution manifestes. Le premier groupe (au moins quatorze espèces) (Ephemerella subvaria, Ephemerella needhami, Ephemerella cornutella, Ephemerella deficiens, Ephemerella serratoides, Epeorus vitrea, Heptagenia hebe, Paraleptophlebia mollis, Tricorythodes sp., Baetis macdunnoughi, Baetis flavistriga, Baetis intercalaris, Baetis pluto et Baetis tricaudatus) n'a été que rarement recueilli dans les réseaux fluviaux aux eaux acides (Medway et Gold), mais dans au moins l'un d'entre eux, le groupe s'y retrouvait en quantité limitée. Pour ce groupe, la distribution est peut-être restreinte par l'acidité des cours d'eau. Le deuxième groupe comprenait sept espèces (Ephemerella dorothea, Ephemerella tuberculata, Ephemerella serrata, Stenonema mediopunctatum, Habrophlebiodes americana, Isonychia sp. 2 et Heterocleon curiosum) qui n'étaient pas présentes dans l'un ou l'autre des réseaux acides - soit à cause d'un pH peu élevé ou des limites de distribution géographique. Un troisième groupe constitué d'au moins cinq espèces: Ephemerella attenuata, Ephemerella funeralis, Stenonema modestum, Heptagenia sp., et Habrophlebia vibrans était tout aussi abondant dans les réseaux fluviaux acides. Un quatrième groupe (deux taxons) était plus largement distribué dans les réseaux acides, soit parce que les individus se sont adaptés au niveau de pH peu élevé, soit parce qu'ils sont tolérants et qu'ils ont profité de l'absence d'espèces concurrentes.

Une liste annotée des diverses espèces recueillies est fournie, ainsi que des aides à l'identification et des reneignements sur la distribution.

INTRODUCTION

The Maritime provinces contain stream systems with a wide diversity of chemical characteristics. Streams in southwestern Nova Scotia are characterized generally by high concentrations of dissolved organic matter and by low pH, while those in southwestern New Brunswick are usually of circum-neutral pH, and have a much lower dissolved organic carbon (DOC) concentration. Several other parameters of stream chemistry may be correlated with DOC and/or pH, such as dissolved calcium, magnesium, aluminum, and iron.

For the last 3 yr, I and several colleagues have been studying the distributions of fish, mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) species in three stream drainage systems: 1) Saint Croix R. system, draining southwestern New Brunswick and emptying into Passamaquoddy Bay (Fig. 1, 2); 2) the Gold R. system, draining an area south of the Kentville-Wolfville axis into the south shore of Nova Scotia (Fig. 1, 3); and 3) the Medway R. system (Fig. 1, 4), draining a section of southwest Nova Scotia to the West of the Gold R. - roughly parallel to the latter system, but separated from it by the LaHave drainage.

While identification of fish species is fairly straight forward, identification of stream insects to the species level can be very difficult - particularly for an area such as the Maritime provinces where this fauna is not well studied, and regional identification keys are not available. This report presents an annotated list of the mayfly species identified. In some instances it has not been possible to associate established species names with the taxa identified, and in others the association is considered tentative. We will attempt to provide sufficient description, where necessary, that others will be able to ascertain whether or not they have a particular taxon described here. This report will also provide background documentation for future quantitative reports. Voucher specimens representative of each of the species listed here have been preserved in ethanol and are available.

STUDY SITES AND COLLECTING METHODS

Twenty-three (numbered 1-25) sites were sampled on the St. Croix system (Fig. 1, 2), 21 sites (31-52) on the Medway (Fig. 1, 4) and 13 (72-84) on the Gold (Fig. 1, 3). We attempted to sample a sufficient number of sites so that replication for various parameters, such as stream size would build some duplication of habitat type into the study (App. I)

Rocky riffle areas only were sampled with standard Surber samplers at all sites with substrate size ranging from gravel to large boulder, so that species associated with pools would be poorly represented in our collections. Three samples were collected at each site at each of five sampling periods spaced regularly from early May until late October-early November. During each sampling period at each site, one sample was taken from substrate containing periphytic vegetation, if present, and one taken

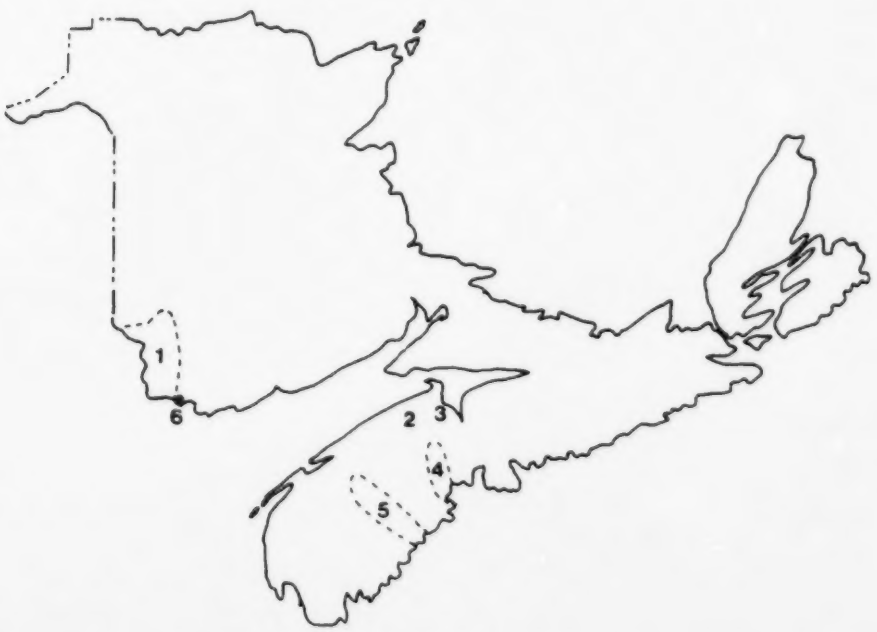

Fig. 1. A map of New Brunswick and Nova Scotia with the approximate drainage areas of the three stream systems studied within dashed lines. 1. St. Croix R. drainage system; 2. Kentville, N. S.; 3. Wolfville, N. S.; 4.Gold R. drainage system; 5. Medway R. drainage system; 6. St. Andrews, N. B.

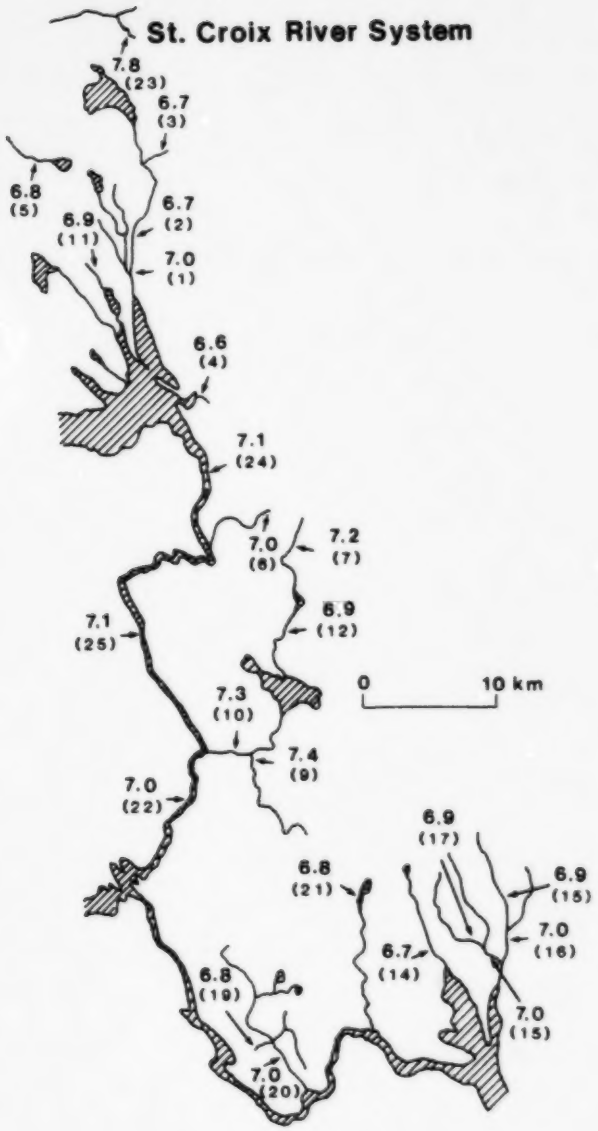

Fig. 2. A detailed map of the St. Croix R. drainage system with locations of study sites shown by arrows. The site numbers are given in parentheses, and a representative mid-summer pH level is given for each site.

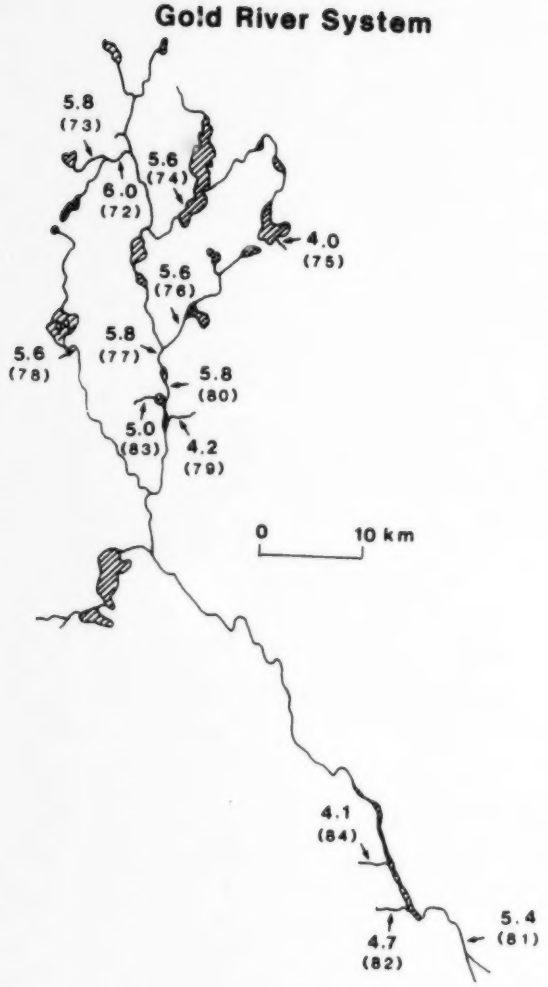

Fig. 3. A detailed map of the Gold R. drainage system. Study sites (numbers in parentheses) indicated by arrows. Representative mid-summer pH levels are shown for each site.

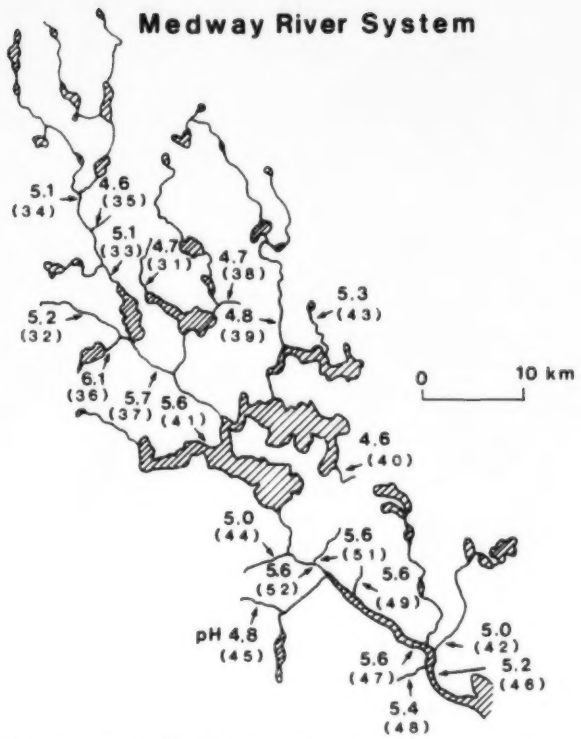

Fig. 4. A detailed map of the Medway R. drainage system. Study sites (numbers in parentheses) indicated by arrows. Representative mid-summer pH levels are shown for each site.

near the stream margin. By systematic temporal sampling through the open water season, and by selecting heterogeneous substrates within the rocky riffle habitat, we hoped to maximize the probability of collecting all or most of the species inhabiting this habitat.

Imagos were also netted when available during the benthic sampling and, for some species, mature nymphs were reared in the laboratory to obtain imagos for species verification.

The references and keys used to identify various taxonomic groups will be given in the sections dealing with these specific groups.

SPECIES IDENTIFICATIONS

FAM. EPHEMERELLIDAE

Nymphs of this family were identified using the series of publications by Allen and Edmunds (1961, 1962, 1963a, 1963b, and 1965). The most difficulty was experienced in attempting to identify nymphs of the subgenus Eurylophella, as will be explained in more detail in the appropriate section.

1. Ephemerella subvaria McDunnough

This species was distinguished primarily by the presence of sharp tubercles on segments 2-9 (Allen and Edmunds 1965). Nova Scotian specimens had pale mid-abdominal tergae unlike most St. Croix specimens. It occupied main stem rivers and tributaries with flowing water year-round, but was absent from smaller brooks and intermittent streams. Its life cycle is out of phase from that of the E. rotunda/invaria species complex with which E. subvaria co-exists at some sites. The adults emerge earlier in the spring (as judged from the absence of mature nymphs in our May collections) - probably late April to very early May. A male imago of this species was reared from nymphs collected in March from site 18. The eggs probably hatched in late summer, and the young nymphs were always more advanced than those of E. rotunda/invaria where they co-occurred. The species may be intolerant of low pH as it was found in only the main stream of the lower Medway R. and upper Gold R., plus one tributary of the Gold system of fairly high pH (ca. 5.5). New Brunswick and Nova Scotia are not within the range shown for E. subvaria in Allen and Edmunds (1965).

Collected at sites: 1, 2, 4, 5, 10, 12, 14, 16, 17, 18, 20, 22, 24, 25, 52, 76, 77, 80.

2. E. rotunda/invaria

This species complex occupied similar habitat to E. subvaria, but was generally more widespread and abundant, particularly below the outfalls of lakes. It was much more widespread than E. subvaria in the acidic Medway system. Its life cycle is phased slightly later than that of E. subvaria, so that when the nymphs of the two species co-occurred, those of subvaria were always further advanced. Most populations had abdominal tergae 5 and 6 less pigmented than the other tergae, but the difference was not so obvious as in some E. subvaria populations. Nymphs of E. rotunda/invaria also had the tergae much more heavily speckled with light dots than were those of E. subvaria. E. rotunda/invaria was frequently the most abundant mayfly where it occurred - in medium to large streams, usually excluded from cooler brooks and intermittent streams.

Collected at sites: 1, 2, 4, 5, 9, 10, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 33, 34, 37, 41, 51, 74, 76, 77, 78, 80, 81.

3. E. aurivilli (Bengtsson)

E. aurivilli was identified from one site (possibly two) in the St. Croix drainage where it was uncommon and apparently associated with Fontinalis moss. The specimens were typical of the eastern form of the species described by Allen and Edmunds (1965). The nymphs had a row of large sub-median pale spots on the tergae and a pale transverse band anterior to the compound eyes. The nymphs appeared to mature in late fall, and were half grown in mid-September. Both sites where it was sampled were larger brooks. The species had not previously been collected from the Maritimes.

Collected at sites: 14 (possibly site 1 also).

4. E. dorothea Needham

Ephemerella dorothea was collected only from the Waweig and Gallop sub-drainages within the St. Croix system. It was sampled from brooks and small rivers, which usually did not dry completely in mid-summer. It was quite distinctive from

local populations of E. subvaria and E. rotunda/invaria in that none of the specimens we collected had any pale tergae - all tergae being a rich, deep brown with whitish speckles (less dense than in E. rotunda/invaria). There were no dorsal abdominal tubercles (Allen and Edmunds 1965). The nymphs probably matured in late June - about 3 wk later than those of E. rotunda/invaria).

Collected at sites: 2, 14, 16, 17, 18.

5. E. needhami McDunnough

This species was distinguishable by the long, sharp tubercles on tergae 2-8 (Allen and Edmunds 1965) - much longer than on any of the species discussed above. Dark dashes and dots on the abdominal sternae were also distinctive. I've collected it only from large rivers below lake outfalls. Its absence from many, apparently suitable sites on the Medway R. would indicate an intolerance to low pH. The nymphs matured in late June (Peterson and Martin-Robichaud 1986).

Collected at sites: 24, 80.

6. Ephemerella (Drunella) walkeri Eaton

E. walkeri was distinguished from other members of the subgenus in the Maritimes by its pointed genal projections, broad frontal shelf and dense hair fringe on the dorsal femora (Allen and Edmunds 1962). Generally distributed in medium to large streams, it was apparently quite pH tolerant as it was also collected from the Jordan R. at pH near 4.5. It was never taken in abundance, probably because it appeared to be associated primarily with habitats consisting of slower moving water. The hairy regions of the nymphs were usually festooned with debris and algal pieces. The nymphs matured in late June to early July, and imagos were collected from emergence traps at site 16. Early instars appeared in some of the early May samples.

Collected at sites: 1, 2, 5, 14, 16, 52, 72, 74, 76, 77, 80.

7. E. (Drunella) cornutella McDunnough

This species was widely distributed in larger brooks or medium to large streams of the St. Croix drainage. Early instars were collected in early May and the nymphs matured in July. It was not collected in the Medway or Gold systems; although Allen and Edmunds (1962) listed collections from a wide distribution of sites in Nova Scotia. E. cornutella was distinguished from the closely similar E. cornuta by smaller size, truncated medial ocellar tubercle (Allen and Edmunds 1962), and a diferent life cycle. Mature nymphs of E. cornuta and immatures of E. cornutella were occasionally present in the same sample.

Collected at sites: 1, 2, 9, 14, 15 16, 17, 18, 23.

8. E. (Drunella) cornuta Morgan

Mature nymphs of E. cornuta were collected from larger brooks and small streams of the St. Croix system in May. It was not collected from Nova Scotia, although it was reported from Cape Breton (Allen and Edmunds 1962). Early instar nymphs attributable to this species were never collected. Since the mature nymphs were quite hairy and covered with detritus, they may have primarily inhabited regions of fairly sluggish current. It was distinguished from E. cornutella on the basis of larger size and the longer, pointed median ocellar tubercle (Allen and Edmunds 1962).

Colected at sites: 2, 12, 15, 18.

9. E. (Drunella) lata Morgan

Ephemerella lata and the next species, E. tuberculata, were collected from larger rivers. Many E. lata specimens from the St. Croix system had a reddish tint with a contrasting, whitish, pro-thoracic dorsum. Both E. lata and E. tuberculata hatched in April-May and the nymphs matured in July-August (Peterson and Martin-Robichaud 1986). Mature male imagos of E. lata were identified from nymphs collected at site 25 and reared in the laboratory.

Collected at sites: 10, 22, 25, 77.

10. E. (Drunella) tuberculata Morgan

E. tuberculata was another species of large rivers, but occurred most commonly below lake outfalls. It was particularly abundant below the outfall of Spednik L. (site 24), whereas E. lata replaced it further downstream. Collections further downstream (site 25) were almost exclusively E. lata. Both species were collected at site 10 (Canoose R.) with E. lata the more abundant. The Maritimes were not included within the range of E. tuberculata by Allen and Edmunds (1962).

Collected at sites: 10, 20, 24, 25.

11. Ephemerella (Serratella) deficiens Morgan

The distinctive, chocolate brown, nymph of this species was widespread in the St. Croix drainage - occurring in medium to large streams. Mature nymphs were collected in late June, and new instars appeared in October. This species was not collected in the Medway system, and at only two sites in the Gold system. Most late stage specimens had the pale median stripe on the thorax and anterior abdomen described by Allen and Edmunds (1963a).

Collected at sites: 1, 2, 5, 9, 10, 14, 15, 16, 17, 18, 20, 21 22, 23, 24, 25, 76, 80.

12. E. (Serratella) serratoides McDunnough

Ephemerella serratoides had a distribution within the St. Croix system similar to that of E. deficiens, but it matures about a month later. E. serratoides probably overwintered in the egg stage while E. deficiens overwintered as early instar nymphs. Early instars of E. serratoides usually had a distinctive whitish patch between the eyes - lost in mature nymphs. Like E. deficiens, E. serratoides was not present in collections from the Medway system, but had a limited distribution in the Gold R. drainage.

Collected at sites: 1, 2, 4, 5, 9, 10, 12, 14, 15, 17, 20, 21, 22, 23, 24, 25, 76, 77, 80, 83.

13. E. (Serratella) serrata Morgan

This species was collected mostly from larger streams, and at site 9, a brook near the confluence with the Canoose R., its presence might have been due to adult strays from the Canoose. Nymphs appeared to mature in mid-July. E. serrata was not collected from Nova Scotia, and its known distributional range does not include Nova Scotia (Allen and Edmunds 1963a). Most specimens collected had tergae 4-6 paler than the others.

Collected at sites: 1, 2, 9, 10, 24, 25.

14. E. (Serratella) sp.

A fourth species of the Seratella subgenus was collected in the main stem of the St. Croix system, which matched none of the species described in Allen and Edmunds (1963a). The specimens examined appeared to have a 2-segmented maxillary palp, whereas E. serrata's is 3-segmented. Another similar species, E. spiculosa has a 1-segmented palp. E. (Serratella) sp. resembles E. spiculosa in having the head and thorax densely covered with fine spicules. The lateral projections of the abdominal sclerites were also much larger than those of E. serrata, while tergae 4-6 were not paler in the specimens collected.

Collected at sites 23(?), 24, 25.

15. Ephemerella (Attenella) attenuata McDunnough

Ephemerella attenuata was collected from main stem rivers and larger tributaries. Its distribution differed from the species discussed previously in that it was collected at more sites in the Medway and Gold drainages than in the St. Croix system. It was tolerant of low pH, having been collected at sites with mid-summer pH levels as low as 4.5. Nymphs matured in late July.

Collected at sites: 2, 10, 17, 20, 24, 33, 37, 39, 42, 52, 74, 76, 77, 80.

16. Ephemerella (Eurylophella) funeralis McDunnough

Ephemeralla funeralis was the only species of the subgenus Eurylophella occurring in the survey collections which could be identified reliably. The presence of well developed sharp tubercles on terga 9, plus well developed occipital tubercles were reliable characters (Allen and Edmunds 1963b). Ephemeralla funeralis was collected from cold brooks of all three drainage systems, and appeared quite tolerant to low pH. Most mature specimens were taken in the spring.

Collected from sites: 3, 11, 14, 17, 19, 31, 35, 44, 73, 83.

17. E. (Eurylophella) spp.

Only mature nymphs (with black wing pads) of other species of the subgenus Eurylophella could be keyed successfully, and these mature nymphs were rarely collected. A few male imagos were reared from nymphs collected at sites 4 and 14, which keyed out to E. prudentalis. The subgenus collectively appeared to be extremely tolerant of low pH.

Collected at sites: 2, 10, 19, 22, 24, 25, 32, 33, 34, 36, 37, 38 39, 41, 42, 43, 44, 45, 47, 48, 51, 52, 72, 73, 74, 76, 77, 78, 80, 81, 82.

FAM. HEPTAGENIIDAE

Stenonema was the most generally distributed genus in the family. For identifications, we have followed the revision of Bednarik and McCafferty (1979) exclusively, although two other revisions were available (Lewis 1974; Spieth 1967).

There were no keys available for Epeorus nymphs. The keys provided by Flowers and Hilsenhoff (1975) and Burks (1973) for Heptagenia were of use, but should be used with caution to identify nymphs of the Maritime region.

18. Stenonema modestum (Banks)

Stenomena modestum was ubiquitous in all three drainage systems, although the Maritimes were not within its listed range (Bednarik and McCafferty 1979). It was collected at all sites, excepting the smallest brooks and intermittent streams, and seemed very tolerant of low pH (Peterson et al. 1985). Imagos were collected from emergence traps installed in the Westfield R. (Peterson et al. 1987).

Collected at sites: 1, 2, 4, 5, 9, 10, 11, 12, 14, 15, 17, 18, 20, 21, 22, 24, 25, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 48, 49, 51, 52, 72, 73, 74, 76, 77, 78, 80, 81, 82, 83, 84.

19. S. luteum (Clemens)

This species and S. vicarium were similar in pattern of sternal banding (Bednarik and McCafferty 1979). The presence or absence of denticles on the fore tarsal claws was used as the primary character in distinguishing between these two species (Bednarik and McCafferty 1979). If immature S. vicarium nymphs had fore-tarsal denticles and lose them later, as apparently occurs in some other species (Bednarik and McCafferty 1979), then some immature nymphs identified as S. luteum may have been misidentified. One nymph was observed with one claw denticulate, the other non-denticulate. S. luteum had not been recorded from the Maritimes previously (Bednarik and McCafferty 1979). It was collected only from medium to large streams in the three drainage systems.

Collected at sites: 1, 9, 12, 14, 15, 16, 18, 20, 22, 47, 49, 52, 76, 77, 78, 80, 81, 83.

20. S. vicarium (Walker)

Stenonema vicarium was collected in all three drainage systems with a great deal of overlap of collection sites with S. luteum. However, its distribution in the Nova Scotian streams, particularly, seemed more restricted to the larger streams. The range of S. vicarium was known to include the Maritimes (Bednarik and McCafferty 1979).

Collected at sites: 1, 5, 9, 14, 18, 20, 23, 25, 33, 47, 78, 81.

21. S. mediopunctatum (McDunnough)

This species was only collected from larger rivers in the St. Croix system. Its previously known range had not included the Maritime provinces, and results of the study indicated that it seemed restricted to the larger, warmer streams in this area. Its absence from the Nova Scotian drainage systems studied may have been due to range limitations.

Collected at sites: 10, 20, 22, 24.

22. Stenonema sp.

Seven specimens of Stenonema were collected which I was unable to assign to any of the above species. They were characterized by about 20 crown maxillae hair setae, lack of fore-claw denticles, and with apparent lateral projections anterior to segment 6. The sternal banding was nearly identical to that of S. ithaca described in Bednarik and McCafferty (1979) - not like that observed for S. vicarium or S. luteum.

Collected at site: 23.

23. Stenacron interpunctatum (Say)

This nymph is thought to prefer pools as opposed to riffle areas of streams (Lewis 1974), and might have been collected more widely had pools been systematically sampled as well. The species is very widespread and morphologically variable with the number and distribution of subspecies still unsettled.

Collected at sites: 4, 5, 16, 17, 18, 20, 31, 34, 49, 52, 72, 78, 81.

24. Cinygmula sp.

Although nymphs of this genus cannot now be identified to species, only one species - C. subaequalis - has been recorded from eastern Canada (Edmunds et al. 1976). Three Cinygmula nymphs were collected at site 15 in May - the only specimens collected. The site was characterized by much ledge rock with pockets of gravel. The stream gradient is steep with water tumbling from one layer of ledge to another.

Collected at site: 15.

25. Epeorus vitrea (Walker)

Two species of Epeorus were sampled. One species, identified as E. vitrea (Peterson and Martin-Robichaud 1986) differed from the other species noticeably as follows: E. vitrea had sub-lateral maculae on the anterior edge of the head capsule. The frontal portion of the head capsule was not quite as expanded as in the other species. The abdominal tergae of E. vitrea featured a medial, longitudinal dark streak; flanked by dark, sub-medial, ovoid maculae. The gills of E. vitrea were not developed ventrally to form a suction disc as in the other species. The other species had a much greater development of a medial setal band on the abdominal tergae.

E. vitrea was most abundant in larger tributaries and rivers. There was probably one brood per year with considerable asynchrony so that several instars were present, particularly in July-August.

Collected at sites: 1, 2, 5, 9, 10, 12, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 76, 80, 81, 82.

26. Epeorus sp.

Morphologically, Epeorus sp. differed from E. vitrea as described for the latter species. The frontal edge of the head capsule had no pale sub-lateral maculae, the gills formed a ventral suction disc, and the abdominal tergae were uniform tan-brown with a well developed medial hair fringe. Epeorus sp. inhabited cooler brooks and appears univoltine with mature nymphs occurring in early June. Early instars appeared in the fall. Epeorus sp. and E. vitrea co-occurred in some larger brooks. Epeorus sp. was collected at only one site in Nova Scotia - a relatively high pH tributary of the Gold R.

Collected at sites: 6, 11, 14, 19, 76.

27. Rhithrogena sp.

This genus was collected only from the main stem of the St. Croix R., and in such low numbers that few comments can be made. One mature nymph was collected in late May.

Collected at sites: 22, 25.

28. Heptagenia hebe McDunnough

At least two species of Heptagenia were collected, but only H. hebe could be identified to species with certainty. I am confident of the identification as the tergal maculation matched the description in Burks (1953), and a male imago was reared from collected nymphs with genitalia matching that described for this species (Burks 1953). It lacks a biramous 7th gill and has denticulate tarsal claws (Flowers and Hilsenhoff 1975). H. hebe was widely distributed in the St. Croix and Gold River systems, but was not collected from the Medway. It occurred in large rivers to medium-sized brooks. Mature nymphs were most frequent in late June-early July.

Collected at sites: 1, 2, 5, 9, 10, 11, 12, 14, 15, 16, 17, 18, 20, 22, 23, 24, 25, 77, 78, 80, 81.

29. Heptagenia sp.

One or possibly two other species of Heptagenia were sampled. The colour patterns of the nymphs were similar to that described for H. diabasia in Burks (1953). The paired sub-medial dashes on the tergae were present in all specimens, as well as the sub-lateral tergal maculae. However, there were some differences between nymphs collected in the two Nova Scotia sampling sites, and those sampled from the St. Croix system. None of the Nova Scotia specimens had the sub-lateral brown sternal bands described by Burks for H. diabasia, and all Nova Scotia specimens had large medial whitish patches on the 8th and 9th tergae - absent in the St. Croix specimens. The faint, brown sternal banding was observed on several of the latter specimens. The 5th and 6th gills of all specimens examined had short terminal

filaments. All nymphs examined had a thin, white line extending from the anterior edge of the compound eye to the lateral margin of the head capsule, rather than the white triangular patches shown in Burks' figure for H. diabasia. The 7th gill was biramous, the anterior head capsule was immaculate brown and the claws were non-denticulate, as compared to the uniramous 7th gill, denticulate claws, and dark-spotted anterior head capsule of H. hebe. One fresh specimen from site 42 was green, but faded to brown with storage in ethanol. I conclude that Heptagenia sp. is either one species or two closely-related species, with the most obvious resemblance to H. diabasia.

Collected at sites: 2, 20, 42, 49, 52, 77, 80.

30. Arthroplea bipunctata (McDunnough)

Two very early instars of this species were collected in early May at site 73. It is normally an inhabitant of pools, rather than running water habitat. These specimens probably drifted out of a slow moving section of the stream.

Collected at site: 73.

FAM. LEPTOPHLEBIIDAE

The most useful reference for the genus Paraleptophlebia was that of Ide (1930). Other references utilized were Burks (1953) and Leonard and Leonard (1962). All keys should be used with caution with late instar nymphs, and identifications suggested by the keys should be checked against the complete species descriptions - particularly those of Ide (1930).

31. Habrophlebia vibrans Needham

Habrophlebia vibrans was widely distributed in all three drainage systems. Our collections indicated a univoltine life cycle with adults occurring in mid- July. Its reported preferred habitat is along edges of small streams with some silt accumulation. However, it was collected in medium-large streams as well; although not to date in the main stem of the St. Croix R. A series of imagos, including several males, were collected from an emergence trap installed at site 16 in mid-July. Habrophlebia vibrans is the only species of the genus occurring in North America.

Collected at sites: 1, 2, 5, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 23, 36, 37, 41, 44, 48, 49, 51, 72, 73, 76, 77, 80, 83.

32. Habrophlebiodes americana (Banks)

The H. americana nymphs were distinguished from Paraleptophlebia nymphs by the deeper median emargination of the labrum. The species was fairly widely distributed in the St. Croix system, but was not found in any samples from Nova Scotia; although Edmunds et al. (1976) commented on its predilection for boggy, acid streams. Its life cycle was similar to that of H. vibrans. Imagos of both species were collected simultaneously from site 16, with H. americana imagos also being netted from sites 1, 2, 9, 17 and 23. Its distribution in the St. Croix system suggested that it was limited to medium-sized streams.

Collected at sites: 1, 2, 9, 10, 15, 16, 17, 23.

33. Paraleptophlebia mollis (Eaton)

Identification of this species was based on the fact that mature nymphs keyed to this species in Burks (1953), relying primarily on gill structure. The gills were cleft about 2/3 the length of the gill. These nymphs matched the description for P. mollis nymphs in Leonard and Leonard (1962). A collection of male subimagos was taken from sites 16 and 18 with genitalia matching that of P. mollis (Burks 1953). These subimagos were netted when mature nymphs identified as P. mollis were collected from these sites. P. mollis was extremely widespread in the St. Croix system, tending to be absent only from the smallest, intermittent brooks and directly below lake outfalls. It was very abundant in most areas where it occurred, and was no doubt an important component of the shredding guild in these streams. Mature nymphs occurred in late spring-early summer with imagos emerging from mid-May to mid-July. Immature nymphs were collected from late July onward.

The nymphs were shiny, dark brown with no abdominal markings. Light maculae occurred between the lateral ocelli and compound eyes. A characteristic short, thin, whitish medial line occurred at the anterior margin of the head capsule which was absent in all other Paraleptophlebia species examined.

Collected at sites: 1, 2, 5, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 41, 77.

Five other species of Paraleptophlebia were distinguished, which I will categorize by number, tentatively associating each of the species with a published species description. In all cases the fit was good, but imagos were not available for many of them.

34. Paraleptophlebia sp. 1

One specimen was collected, characterized by gills less deeply cleft than those of P. mollis, and with more extensive tracheal branching. The head capsule maculation differed from that described for P. mollis in that no pale medial stripe occurred on the anterior head capsule, but a large pale patch just anterior to the medial ocellus was present. From the description provided in Ide (1930) and Burks (1953), I tentatively associated this species with P. adoptiva (McDunnough). Both P. mollis and P. sp. 1 have very long, dense setae on the maxillary palps, extending well beyond the tips.

Collected at site: 19.

35. Paraleptophlebia sp. 2

I tentatively associated this species with P. volitans (McDunnough) as described by Ide (1930). The gills were more deeply cleft than those of P. mollis (trachea branch 1/7 the distance from the base, as described by Ide 1930). There was no tracheal side-branching. Sharp postero-lateral spines occurred on both segments 8 and 9. The gills had considerable marginal hair, but this was an unreliable taxonomic feature as several other species also had sparse marginal hairs. Ide's (1930) figure of the gill was useful. The tergae were marked as described by Ide (1930), with

usually two small, light sub-median spots on tergae 3-7 as well as a more vague pale lateral spot just medial to the blackish stigmatal dash. The legs were vaguely banded distally on the femora and proximally on the tibia and basal tarsal segment as in Ide (1930). Paraleptophlebia sp. 2 was found to be associated with warm habitats below lake outfalls, usually in larger streams. Mature nymphs were collected in late July.

Collected at sites: 5, 20, 21, 33, 42, 47, 52, 72, 74, 76, 77, 78, 80, 81.

36. Paraleptophlebia sp. 3

This species and the following two were all characterized by very deeply cleft gills, with trachea dividing about 1/10 the distance from the base and with very thin pinnae and no tracheal side branching. There were often some sparse marginal hairs. Paraleptophlebia sp. 3 had postero-lateral spines on abdominal segments 8 and 9, whereas the next two species had spines only on segment 9. The maxillary palp for P. sp. 3 was as described in Ide (1930) for P. debilis (Walker), as were the tergal markings. The tergae had a pair of small, sub-median dashes diverging posteriorly. The femora had brown banding 2/3 the distance from the base, at mid-tibia, and at the proximal end of the tarsal base. From the characters described above, I tentatively associated P. sp. 3 with P. debilis, as described by Ide (1930). This species was collected only from small, cool brooks - frequently associated with Eurylophella funeralis.

Collected at sites: 3, 6, 7, 19, 38, 51, 73.

37. Paraleptophlebia sp. 4.

This species and the next were similar in having postero-lateral spines only on the 9th abdominal segment; and long, slender maxillary palps with tufting on the end of the terminal segment. The gills of both these species were deeply cleft, as described for P. sp. 3. Paraleptophlebia sp. 4 and P. sp. 5 were more slender than the other species described, with longer legs proportionately - appearing superficially at least to be adapted to slower water currents. P. sp. 4 was tentatively identified as P. strigula as I associated a nymphal skin from a nymph collected at site 25 and laboratory reared with a male imago identified as P. strigula (McDunnough) (Burks 1953). Nymphs of P. sp. 4 had been collected at site 25 as well. The lateral margins of the tergae had black streaking, as described in Burks (1953) key for this species, and there was often considerable blackish pigmentation elsewhere on the tergae. P. strigula was collected only from larger streams.

Collected at sites: 10, 12, 25.

38. Paraleptephlebia sp. 5

This species was similar to P. sp. 4, differing primarily in the tergal markings. The tergae were brown with small, blackish stigmatal spots. From its similarity to Ide's (1930) description and conclusions drawn from Burks' (1953) key, I tentatively associated P. sp. 5 with P. guttata (McDunnough). This species was collected from one site on the Gold system.

Collected at site: 77.

39. Leptophlebia sp. 1

The nymphs of two readily separable species of Leptophlebia were collected in the two Nova Scotian stream systems. Although Leptophlebia imagos and subimagos were collected at several St. Croix sites, no nymphs were collected in the lotic areas sampled. Since the genus is considered to primarily inhabit backwaters and regions of sluggish current, its presence in lotic habitats in the Medway and Gold systems may be considered unusual. One might speculate that they were in this habitat due to the absence of possible competitors, such as P. mollis. Peterson et al. (1986) commented on the presence of early Paraleptophlebia instars in some acidic Nova Scotian streams, but the absence of later instars. Early Leptophlebia instars do not have the lateral flanges of the gills developed and can be misidentified as Paraleptophlebia nymphs. I feel that this was possibly the case in Peterson et al. (1986). By systematic sampling, and subsequent examination of series of nymphs, this possibility was avoided in this study.

The two species of Leptophlebia nymphs could be most readily distinguished by the markings of the 10th abdominal terga. That of Leptophlebia sp. 1 (the larger of the two species) was dark reddish-brown with two submedial, elongated light maculae and a narrow light median stripe (Fig. 5a). The 10th terga of Leptophlebia sp. 2 is light tan with a single, dark median macula (Fig. 5b).

Early instars of Leptophlebia sp 1 appear in the fall, and mature nymphs were collected in mid-May to mid-June.

Collected at sites: 31, 32, 33, 34, 35, 36, 37, 40, 43, 44, 45, 46, 49, 72, 75, 78, 79, 83, 84.

Fig. 5. Patterns of markings on the 10th abdominal tergae for the two species of Leptophlebia nymphs collected.

40. Leptophlebia sp. 2

Leptophlebia sp 2 could be distinguished from L. sp. 1 by the 10th tergal pattern as described above. Mature nymphs of L. sp. 2 were collected in late July. Both species co-existed at a few sites with L. sp. 1 present in the spring and fall, and L. sp. 2 collected in the summer. L.

sp. 2 was collected from small, spring-fed brooks and intermittent trickles, while L. sp. 1 was found in larger brooks and rivers as well. The genus was very acid tolerant, being abundant in very acidic brooks where other Ephemeroptera were absent.

Collected at sites: 35, 38, 45, 73, 75, 79, 83, 84.

FAM. SIPHLONURIDAE

No keys were available for nymphs of this family of mayflies. Two species of Isonychia nymphs, and one of Siphlonurus were distinguishable.

41. Isonychia sp. 1

I. sp. 1 was the most frequently encountered, and was characterised by a lack of sternal submarginal maculation. The antennal pedicel was pale dorsally; although some variable brown shading could occur laterally. The 10th abdominal tergite was mostly dark brown with variable light shading basally. Mature nymphs were collected in July, and early instars in late summer. Isonychia sp. 1 was widespread in medium-sized to large streams.

Collecteed at sites: 1, 2, 4, 5, 9, 10, 12, 15, 20, 21, 22, 33, 34, 47, 49, 77, 78, 80.

42. Isonychia sp 2.

I. sp. 2 differs from I. sp 1 in having dark sub-lateral maculae on the abdominal sternae. The antennal pedicel is solidly brown, while the 10th terga is strongly contrasting whitish basally and dark brown to black distally. Mature nymphs are somewhat smaller than those of I. sp. 1.

Collected at sites: 1, 2, 5, 20.

43. Siphlonurus sp.

This genus, like Leptophlebia, usually inhabited still water regions of streams; hence was seldom collected in lotic habitat. It was abundant in one sample at site 73, a cool brook with a dense growth of Fontinalis moss.

Collected at sites: 73, 78.

FAM. TRICORYTHIDAE

Most members of this family do not inhabit lotic stream areas, but Tricorythodes sp. was sampled regularly. There were no available species keys for any nymphs in this family.

44. Tricorythodes sp.

Nymphs of this genus primarily inhabited regions of sluggish current, and were usually festooned with debris. However, they were collected frequently from sites in warmer stream habitats - frequently associated with lake outfalls. Adults of two species, T. stygiatus and T. atratus have been collected, but no attempt is made here to distinguish nymphs to species. Tricorythodes nymphs were collected in July and August. They were apparently intolerant of acidic conditions, as they were not collected in the Medway R. system, though many otherwise suitable sites were sampled. They were sampled from three of the less acidic sites in the Gold system.

Collected at sites: 1, 2, 9, 10, 12, 16, 20, 21, 23, 24, 25, 76, 77, 80.

FAM. BAETIDAE

I have relied solely on Morihara and McCafferty (1979) for identification of Baetis nymphs, with Burks (1953) being useful for some imagos. The former reference provides clear identifications for most of the species encountered. Some difficulties arose with specimens of the B. propinquus group, and the identification of B. brunneicolor is considered tentative. No species keys were available for Pseudocleon nymphs; however, Ide (1937) provides descriptions of some species.

45. Baetis pygmaeus (Hagen)

B. pygmaeus was easily determined by the presence of the lanceolate 7th abdominal gill (Morihara and McCafferty 1979). Male imagos were reared from nymphs collected at site 25. B. pygmaeus occurred in medium to large streams, and is often abundant below lake outfalls. There were probably more than one generation per year. B. pygmaeus was one of the more pH tolerant Baetis species, occurring throughout the main stem of the Medway system, but not in more acidic tributaries.

Collected at sites: 1, 2, 4, 5, 9, 10, 12, 15, 16, 17, 18, 20, 21, 22, 24, 25, 33, 34, 36, 37, 47, 49, 52, 72, 76, 77, 78, 80.

46. B. macdunnoughi Ide

Baetis macdunnoughi was another easily identified Baetis species by virtue of its distinctively shaped 7th gill plate (Morihara and McCafferty 1979). Taxonomically it is related to B. pygmaeus, but the two species were well separated ecologically. Baetis macdunnoughi was an inhabitant of cool brooks whereas B. pygmaeus was most abundant in larger, warmer streams. The distributions of the two species overlapped in some medium-sized streams. The distribution of B. macdunnoughi appeared to be restricted by low pH in the Medway and Gold systems, as the cool brooks preferred by this species were often the most acidic habitats. Nymphs of this species were often present throughout the summer.

Collected at sites: 1, 2, 3, 6, 9, 11, 14, 15, 16, 17, 18, 19, 23, 44, 73, 83.

47. B. flavistriga McDunnough

Baetis flavistriga was distinguishable by the characters described by Morihara and McCafferty (1979), i.e. the dark, inverted "u" mark on the pronotum, paired, large, pale, kidney-shaped spots, on the posterior half of the tergites, banded tails, and broad labial palps (Morihara and McCafferty 1979). The coloration tends to fade in preserved specimens, so that identification is best performed on specimens collected fairly recently (i.e. within 1 yr). This species occupied larger brooks to large rivers - frequently co-habiting sites with B. pygmaeus. Nymphs were collected from May until late September, with mature specimens collected from late July onward.

Male and female imagos were reared from nymphs collected at site 25. This species is probably quite intolerant of low pH as it was not collected from the Medway system, and only from sites of fairly high pH in the Gold system.

Collected at sites: 1, 2, 4, 5, 9, 10, 12, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25, 76, 77, 80, 81.

48. B. intercalaris McDunnough

The nymphs of this species were very similar to those of B. flavistriga, differing only in the pattern of light spots on the abdominal tergae. Baetis flavistriga had the two large, kidney-shaped spots, while B. intercalaris had three rounded spots of nearly equal size along the posterior half of the tergae (Morihara and McCafferty 1979). As with B. flavistriga, these spots faded after more than a year or two in ethanol. Morihara and McCafferty (1979) considered the possibility that B. flavistriga and B. intercalaris were conspecific. A male imago of B. intercalaris (as described by Burks (1953)) was collected at site 16, and was distinctly different from the B. flavistriga male imagos reared in the laboratory, particularly the size of the turbinated eyes (as noted in Burks (1953)). Baetis intercalaris nymphs were collected infrequently, and usually at sites where B. flavistriga was also collected.

Collected at sites: 16, 19, 20, 21, 22, 23, 77.

49. B. pluto McDunnough

This species is distinguished by the presence of banded caudal filaments and slender labial palps (Morihara and McCafferty 1979). The dorsum of the nymph was usually a uniform brown, generally darkening as the nymph matures. In the darkest specimens, there were occasionally no dorsal marks, although usually some vague, darker, submedial spots were noticeable on the tergae. In lighter specimens the 5th terga was sometimes whitish with paired, sub-medial, longitudinal darker streaks on the anterior half. In darker specimens the cerci were dark on the basal half to two-thirds, followed by a white band, then dark tips. The medial caudal filament was about 60% of the length of the cerci and similarly banded with the basal dark portion extending an equal length with those on the cerci. In lighter forms, the basal dark portion was often interrupted by a whitish band.

Baetis pluto was collected from medium to large streams, frequently in the same samples as B. flavistriga and B. pygmaeus - but usually not so abundant as these other two species. B. pluto had limited distribution in the Gold system, and was not collected from the Medway.

Collected at sites: 1, 2, 4, 5, 9, 10, 11, 14, 17, 19, 20, 21, 23, 74, 76, 77, 80.

50. B. tricaudatus Dodds

Baetis tricaudatus was distinguished by unbanded caudal filaments and the dark, bilaterally lobed submedial marks on the pronotum (Morihara and McCafferty 1979). The labial palps were fairly broad, but not as broad as those of B. flavistriga or B. intercalaris. Paired dark sub-medial dots were often present on the tergae of which numbers 5 and 9 could be lighter in colour. Baetis tricaudatus was sampled from habitats ranging from larger brooks to fairly large rivers; although I've not identified it from the main stem of the St. Croix R. It was not so widespread or abundant as B. flavistriga or B. pluto. Baetis tricaudatus was particularly abundant at site 14 (Gallop Stream), and was also common in the main stem of the Gold system where some very dark, mature specimens were taken in early May. Baetis tricaudatus was not found in the Medway system.

Collected at sites: 10, 14, 15, 23, 77, 80, 81.

51. B. brunneicolor McDunnough

I have tentatively assigned several nymphs to this species on the basis of unbanded caudal filaments and the lack of any distinctive markings on the thorax or abdomen (Morihara and McCafferty 1979). There was frequently a paler median stripe on the tergae. The medial projection of the 2nd segment of the labial palp was well developed, but the palp itself is slender. Some small, ocellate submedial tergal spots were also usually discernible. Our few specimens were collected in June from small brooks.

Collected at sites: 3, 6, 51.

52. Baetis sp. (propinquus group)

Specimens belonging to this Baetis group were collected from three sites. The group was characterized by a distal lobe on the antennal scape, and a sub-apical excavation on the maxillary palps. The species could have been B. propinquus as the submarginal labial setae appeared unbranched when examined at high power. Specimens of this group were collected too sparingly to permit comments on distribution.

Collected at sites: 1, 5, 6.

53. Heterocleon curiosum McDunnough

This genus was distinguished by the presence of a thread-like gill at the base of the forelegs (Edmunds et al. 1976). Failure to note this feature might lead to misidentification as a species of Pseudocleon. Since only one species of the genus has been found in eastern Canada (Edmunds et al. 1976), I assume that our specimens were of this species. The specimens collected were pale brown, usually with paired triangular submedian pigment patches of darker brown. These patches may fuse into a single large medial patch. There were also usually darker pigment patches sub-laterally on the meso-thorax. The tails are unbanded, and the gills were pigmented centrally with branching tracheae. This species was collected from warmer habitats - larger streams and lake outfalls - in the St. Croix system. The boulders at these collecting sites were covered with moss or other macrophytic vegetation.

Collected at sites: 2, 10, 20, 21, 24, 25.

54. Pseudocleon punctiventris (McDunnough)

Many specimens which I include in this species lack the median black sternal dots - a distinguishing feature of the species (Ide 1937). Ide stated that some of his specimens also lacked the dots. Specimens with and without the dots were invariably collected together, those lacking dots usually predominant. The two forms appear identical in other respects. Pseudocleon punctiventris was abundant and widespread in all three stream systems, and is obviously tolerant of low pH. It was particularly abundant in warmer habitats, such as larger streams and below lake outfalls.

Collected at sites: 1, 2, 4, 9, 15, 16, 22, 24, 25, 31, 32, 33, 34, 36, 37, 38, 39, 41, 42, 43, 47, 48, 49, 52, 73, 74, 76, 77, 78, 80, 81, 83.

55. Pseudocleon spp.

Other Pseudocleon species were collected at several sites. A mature nymph was collected at site 2, and a male and female imago from site 16. Some specimens resembled the description of P. dubium (Ide 1937), but exhibited differences in the tergal color pattern.

Collected at sites: 1, 2, 9, 15, 16.

DISTRIBUTIONAL PATTERNS

The evidence gathered from the collections suggests that several species may be limited in their distribution by low pH. Among these are Ephemerella subvaria, E. needhami, E. cornutella, E. deficiens, E. serratoides, Epeones vitrea, Heptogenic hebe, Paraleptophlebia mollis, Tricorythodes sp., Baetis macdunnoughi, B. flavistriga, B. intercalaris, B. pluto and B. tricaudatus; all these species, which are widely distributed and often abundant in the St. Croix system, of circumneutral pH, are of very limited distribution or absent from the Medway system - the most acidic system of the three sampled. For example, E. subvaria was collected from a wide variety of stream sizes in the St. Croix system (14 of 23 sites), whereas it was only collected from one Medway site on the main stem - a site of relatively high pH, despite the fact that there are 12 other Medway sites with the range of stream sizes inhabited in the St. Croix system. This suggests that the species distribution has been restricted in the Medway drainage system. It is unlikely that any of these species which are absent from the Medway system are excluded for zoogeographic reasons (range limitation), because they are present in suitable habitat in the Gold system where the pH is sufficiently high.

Several other species were absent from both the Gold and Medway systems, hence their absence was due either to low pH or due to the fact that these Nova Scotian streams lie outside their range. Species in this category are Ephemerella dorothea, E. tuberculata, E. serrata, Stenonema mediopunctatum, Habrophlebiodes americana, Isonychia sp. 2, and Heterocleon curiosum.

A third group of species are widely distributed in all three stream systems and so appear to be tolerant of low pH, such as A. attenuata, E. funeralis, S. modestum, Heptagenia sp., and H. vibrans.

Finally, a fourth group of species were more widely distributed in the low pH systems, either through adaptation to an acidic environment or to exploitation of a wider range of habitat possible due to loss of competitive species. In this group are the two Leptophlebia species and Pseudocleon punctiventris. We encountered possibly one identifiable taxon (Leptophlebia sp. 2) in the Nova Scotian stream systems that were not collected from the St. Croix drainage. However, as was stated in the species notes, Leptophlebia characteristically does not inhabit lotic environments. The Nova Scotian collections of Leptophlebia were unusual in this regard. The possible absence of Leptophlebia sp. 2 from the St. Croix would have to be documented more thoroughly by sampling pools and backwater areas - the usual habitats of these organisms.

The other species identified in this study were not assigned to any of the above categories for at least one of three reasons: 1) the taxon was encountered too infrequently to discern any distributional pattern; 2) the identification was tentative; 3) more refined analysis would be required to categorize the distribution.

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APPENDIX I. Names and brief descriptions of the various study sites from which Ephemeroptera were collected

ST. CROIX SYSTEM STUDY SITES

Site #			
	1.	Palfrey Stream	Small river.
	2.	Palfrey Stream	Upstream of site 1, large brook with steeper gradient than site 1. Just below a fairly extensive deadwater area.
	3.	Unnamed	Small, spring-fed brook. Intermittent in dry summers.
	4.	First Lake Outlet	River, 200 m below lake.
	5.	Outlet of Third Eel L.	Medium brook, 2.5 km below 3rd Eel L.
	6.	Trout Brook	Small brook, intermittent in dry summers. Study site was in section channelized during highway construction. Now overgrown with alders.
	7.	Unnamed	Small brook. Short section of riffle below extensive beaver flowage.
	9.	Green Brown Brook	Medium brook. Study site 100 m above confluence with Canoose R.
	10.	Canoose River	Medium river. Study site 7 km below Canoose Lake.
	11.	East Brook	Medium brook.
	12.	Canoose River	Small river. Upstream of Canoose L., 3 km below an extensive flowage.
	14.	Gallop Stream	Large brook.
	15.	Sawyer Brook	Large brook.
	16.	Waweig River	Small river.
	17.	McCarley Brook	Medium brook.
	18.	Pout Brook	Medium brook.
	19.	Unnamed	Small, spring-fed brook - not intermittent.
	20.	Mohannes Stream	Small river.
	21.	Dennis Stream	Small river. Study site 40 m below Moore's Lake.
	22.	St. Croix River	Large river. Most downstream site on the St. Croix R. Above the Grand Falls flowage.
	23.	Dead Creek	Medium brook.
	24.	St. Croix River	Large river. 200 m below Spednik L.
	25.	St. Croix River	Large river, at "Gravel Island". About 20 km below site 24.

MEDWAY SYSTEM STUDY SITES

31.	Moose Pit Bk.	Medium Brook.
32.	Mount Merritt Bk.	Medium Brook.
33.	Medway River	Medium river, 1 km above Dean L.
34.	Medway River	Medium river. Very steep gradient, 50 m below a flowage.

APPENDIX I. (cont'd)

Medway System Study Sites (cont'd)

35.	Unnamed	Small, spring-fed brook.
36.	Harmony Stream	Medium brook, 50 m below Harmony L.
37.	Medway River	Large river, 2 km below confluence with McGoveon and Harmony Lakes.
38.	Halfway Brook	Medium brook.
39.	Pleasant River	Medium river.
40.	Unnamed	Small brook, 100 m below beaver flowage.
41.	Outlet of First Christopher L.	Medium river, 100 m below extensive lake system.
42.	Limestone Brook	Large brook.
43.	Keddy Brook	Small brook.
44.	Fifteen Mile Brook	Medium brook.
45.	Twelve Mile Brook	Medium brook.
46.	Unnamed	Channelized spring seepage, flows into roadside ditching - intermittent.
47.	Medway River	Large river, most downstream site on the main Medway.
48.	Tumblingdown Brook	Medium brook.
49.	Wentworth Brook	Large brook, considerable deadwater area upstream of study site.
51.	Buggyhole Brook	Medium brook, study site 70 m above confluence with Medway.
52.	Medway River	Large river.

GOLD SYSTEM STUDY SITES

72.	Seffern's Lake Outlet	Small brook, 50 m below lake.
73.	Unnamed	Small brook, spring-fed.
74.	Wallaback Lake Outlet	Large brook, 100 m below lake.
75.	Unnamed	Small, spring brook, intermittent in dry summers.
76.	Mill Brook	Large brook, very steep gradient.
77.	Gold River	Medium river, at New Ross.
78.	Larder River	Small river, 2 km below Lake Ramsay.
79.	Skerry Cobbler Brook	Small, cold brook.
80.	Gold River	200 m below Lake Lawson.
81.	Gold River	Large river, near head of tide.
82.	Unnamed	Medium brook.
83.	Bench Brook	Small brook.
84.	Unnamed	Seepage into roadside ditch, intermittent.